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Proceedings of the Regional Assessment of an Eastern Scotian Shelf Shrimp (*Pandalus borealis*) Framework

April 14-15, 2015
Dartmouth, Nova Scotia

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Foreword

The purpose of these Proceedings is to document the activities and key discussions of the meeting. The Proceedings may include research recommendations, uncertainties, and the rationale for decisions made during the meeting. Proceedings may also document when data, analyses or interpretations were reviewed and rejected on scientific grounds, including the reason(s) for rejection. As such, interpretations and opinions presented in this report individually may be factually incorrect or misleading, but are included to record as faithfully as possible what was considered at the meeting. No statements are to be taken as reflecting the conclusions of the meeting unless they are clearly identified as such. Moreover, further review may result in a change of conclusions where additional information was identified as relevant to the topics being considered, but not available in the timeframe of the meeting. In the rare case when there are formal dissenting views, these are also archived as Annexes to the Proceedings.

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SUMMARY

The northern or pink shrimp, *Pandalus borealis*, is the only shrimp species of commercial importance in the Fisheries and Oceans Canada (DFO) Maritimes Region. The fishery consists of 28 DFO Maritimes Region-based licences (fished by 9 vessels in 2014), mostly <65' length overall (LOA) and 14 DFO Gulf Region-based licences (fished by 5 vessels in 2014), 65-100' LOA. All mobile licenses have been under Individual Transferable Quotas (ITQs) since 1998. A competitive trap fishery with 14 licenses (7 active in 2014) is largely restricted to Chedabucto Bay. The status of Eastern Scotian Shelf shrimp was last fully assessed by DFO Science on November 27, 2014 (DFO 2015). As part of the Regional Science Advisory Process, a northern shrimp of the Eastern Scotian Shelf framework assessment science advisory meeting was held April 14-15, 2015, at the Bedford Institute of Oceanography, Dartmouth, Nova Scotia. A working paper was provided to meeting participants on April 7, 2015, ahead of the meeting. Overall conclusions of the meeting were:

1. the Traffic Light Approach should continue to be pursued and refined where possible (e.g. add a trap catch index);
2. a Bayesian Model analytical approach yielded inconclusive results, as dynamics of this stock are driven by extrinsic factors (i.e., environmental) rather than by fishing mortality;
3. the current assessment approach does not support a direct linkage with Harvest Control Rules (HCR) and therefore HCRs should not be pursued at this time; and
4. triggers for a move from an interim update to a full stock assessment (during the interim update years) should be identified using core indices, retrospective analysis, and in comparison with other fisheries.

A Science Advisory Report (SAR) was not a product of the meeting. Participants agreed that provided the working paper incorporated comments made at the meeting, it was acceptable for publication as a Research Document. This Proceeding constitutes a record of the meeting discussion.

SOMMAIRE

La crevette nordique ou crevette rose, *Pandalus borealis*, est la seule espèce de crevette d'importance commerciale dans la région des Maritimes de Pêches et Océans Canada (MPO). Vingt-huit (28) permis de pêche ont été accordés pour cette pêche dans la région des Maritimes du MPO (neuf navires en 2014), dont la plupart mesuraient moins de 65 pi de longueur hors tout (LHT). Quatorze permis ont été accordés dans la région du Golfe du MPO (cinq navires en 2014, de 65 à 100 pi de LHT). Depuis 1998, tous les permis de pêche pour engins mobiles ont été délivrés pour des quotas individuels transférables (QIT). Une pêche concurrentielle au casier regroupant 14 titulaires de permis (dont sept avaient des permis actifs en 2014) est limitée en grande partie à la baie Chedabucto. L'état de la crevette de l'est du plateau néo-écossais a été entièrement évalué pour la dernière fois par le Secteur des sciences de Pêches et Océans Canada (MPO) le 27 novembre 2014 (MPO 2015). Dans le cadre du processus d'avis scientifique régional, une réunion de consultation scientifique pour l'évaluation du cadre de la crevette de l'est du plateau néo-écossais s'est tenue à l'Institut océanographique de Bedford, à Dartmouth, en Nouvelle-Écosse, les 14 et 15 avril 2015. Un document de travail avait été fourni aux participants le 7 avril 2015, avant la réunion. Les conclusions générales de la réunion sont les suivantes :

1. la méthode des feux de circulation devrait être appliquée et améliorée, dans la mesure du possible (p. ex. ajouter un indice des prises par casier);
2. les résultats de l'approche analytique du modèle bayésien n'étaient pas concluants, car la dynamique de ce stock est régie par des facteurs extrinsèques (c.-à-d. environnementaux) plutôt que par la mortalité par pêche;
3. l'approche d'évaluation actuelle ne fait pas de lien direct avec les règles de contrôle des prises (RCP) et, par conséquent, elle ne peut être adoptée pour le moment; et
4. il convient de déterminer, à l'aide d'indices de base, d'analyses rétrospectives et en effectuant une comparaison avec d'autres pêches, les éléments permettant de passer d'une mise à jour provisoire à une évaluation complète du stock.

Aucun avis scientifique (AS) n'a été produit pendant la réunion. Les participants ont convenu que du moment que le document de travail comportait les commentaires formulés pendant la réunion, il pouvait être publié en tant que document de recherche. Ce compte rendu constitue un enregistrement de la discussion de la réunion.

INTRODUCTION

The northern or pink shrimp, *Pandalus borealis*, is the only shrimp species of commercial importance in the Fisheries and Oceans Canada (DFO) Maritimes Region. The fishery consists of 28 DFO Maritimes Region-based licenses (fished by 9 vessels in 2014 mostly <65' length overall (LOA)) and 14 DFO Gulf Region-based licences (fished by 5 vessels in 2014 that were 65-100' LOA). All mobile licences have been under Individual Transferable Quotas (ITQs) since 1998. A competitive trap fishery with 14 licenses (7 active in 2014) is largely restricted to Chedabucto Bay. The fishery operates under an "evergreen" management plan, which documents sharing agreements between fleet sectors. Previously, science advice was provided on an annual basis, with full peer review and industry participation occurring up to and including 2012. For the 2013 year, a change was incorporated into the assessment whereby a full assessment of the fishery was to take place every two years, with interim advice provided in interim years. The first interim advice was provided in 2013, based on a complete analysis of the data (DFO 2014). In 2014, the status of Eastern Scotian Shelf shrimp was again fully assessed by DFO Science on November 27, 2014 (DFO 2015). This was to be followed by an assessment of the fishery framework and interim update in 2015.

A northern shrimp of the Eastern Scotian Shelf (ESS) framework assessment science advisory meeting was held April 14-15, 2015, at the Bedford Institute of Oceanography, Dartmouth, Nova Scotia. The meeting Chair-person, Mr. Thomas Wheaton, first introduced himself, followed by an introduction of meeting participants (Appendix 1). The Chair thanked meeting participants for attending the DFO Science Advisory Process. The overall objectives of the meeting were:

1. update descriptive information related to the fishery, the survey, biology, and ecosystem interactions of the target species;
2. review the assessment framework and identify if alternative approaches to assessing the fishery can be pursued (review the Traffic Light Analysis (TLA) and biological basis for considering each index to be relevant to the shrimp stock; review alternate approaches to summarizing TLA data that provides advice more directly related to Harvest Control Rules (HCR); and review alternate assessment models, such as a biomass dynamic model);
3. evaluate bycatch of non-target species in observed trips in the shrimp fishery; and
4. identify how advice is to be provided in interim years versus full advice assessment years.

The Chair provided a brief overview of the Canadian Science Advisory Secretariat (CSAS) science advisory process and invited participants to review the meeting Terms of Reference (Appendix 2) and Agenda (Appendix 3). No revisions or additions were made to the Terms of Reference or Agenda. To guide discussion, a working paper was provided to meeting participants on April 7, 2015, ahead of the meeting. A Science Advisory Report (SAR) was not a product of the meeting. This Proceeding constitutes a record of the meeting discussion.

PRESENTATION AND DISCUSSION

REVIEW OF WORKING PAPER

Working Paper: Hardie, D., M. Covey, and A. Cook. 2015. 2015 Eastern Scotian Shelf Shrimp Framework. CSAM Working Paper 2015/09.

Science Lead: D. Hardie (Working Paper)
Rapporteur: K. Curran

Introduction

The science lead, Dr. David Hardie, reviewed the fishery and surveys. Bycatch was initially discussed, followed by a discussion on the DFO-Industry Trawl Survey (or Trawl Survey), and survey biomass index and commercial catch rates indices, as proxies for stock biomass. The indices provided a basis for discussion of the Bayesian model that was explored as an additional assessment tool for the species. The lead then provided an overall summary of the TLA used as a framework for assessing the stock, including a discussion on Harvest Control Rules and the interim assessment approach (and triggers of a full stock assessment in interim assessment years). Last, additional research recommendations in support of the fishery were discussed.

Bycatch

The science lead reviewed a map of bycatch observer coverage sets from 2004-2014. It was noted that the Integrated Fishery Management Plan (IFMP) for the fishery indicates that up to 5% of all fishery trips are to be observed, although the IFMP identifies a minimum of one trip in each of SFAs 13-15 (industry typically aims to achieve 5% observer coverage). It was further noted that bycatch coverage generally aligns with locations of fishing effort in any given year. A reviewer suggested the percentage of observed fishing hours is low, although bycatch of non-target species is also low for the fishery. In general, only a dozen or so bycatch species have been observed consistently over the past decade, with the proportions of these species only accounting for a fraction of a percent, up to a few percent, of overall target stock biomass that is caught. The reviewer felt the bycatch analysis adequately addressed questions raised at the recent shrimp assessment meeting held in December 2014 (DFO 2015). It was suggested, however, that information on the percent coverage by hours fished be added to a Research Document to be completed following the meeting. The science lead clarified that 0.01-0.03% of reported fishing hours are covered by observers annually in the fishery.

Another reviewer inquired as to why observer coverage was high in 2010, and it was explained that this was the result of two independent observer companies conducting coverage of the fishery in this year. The anomaly was unintended and not the result of any concern regarding conduct of the fishery; again, the annual target for observer coverage is 5%. With this clarification, the reviewer remarked that although bycatch is low the observer coverage is also low. Given that select bycatch species appear patchy in the data presented, there may be a need for more observer coverage to acquire a more detailed picture or be more strategic in identifying observer trips that allow for increased overlap where the fishery interacts with co-occurring species that are typically caught as bycatch. The reviewer further noted that most bycatch is small in size, and this could result in low bycatch rates by mass but not necessarily by number (relative to catch observed in the Trawl Survey). It was suggested bycatch be assessed both by mass and by number for comparative purposes.

The science lead stated that industry tries to avoid areas of high bycatch, such as flounder. The Trawl Survey, however, is based on pre-selected sample locations; consequently, it is difficult to

compare bycatch results from observer data to Trawl Survey catch data. In addition, the science lead explained that industry gear continues to evolve to minimize bycatch (i.e., use of a bycatch separator), whereas the Trawl Survey does not have this type of gear in use. A meeting participant from industry further noted that lights are now being used by the Gulf of St. Lawrence shrimp fleet to minimize bycatch in this region, and that this technique has also been used in Oregon, USA (this practice has been demonstrated to scare away fish). It was clarified, however, that at this stage the approach is only being explored but, if effective, would likely be adopted by the Scotian Shelf shrimp fleets. The meeting participant commented that results from the Gulf fleet experience will be shared with DFO as they become available.

It was pointed out that in a couple of pre-2000 reports, Trawl Survey catch was analyzed by number and by weight. These reports indicated that a higher percentage of small flounders and Greenland halibut were observed in the Trawl Survey compared to observer results. The survey gear has maintained a configuration that the commercial fleet has moved away from to avoid flatfish as bycatch, so there is reason to believe the Trawl Survey flatfish catch over-represents bycatch of these species and could be considered to represent a 'worst-case scenario' of bycatch that may result from the fishery (given that the Trawl Survey and industry observer data are not easily comparable). In general, it was agreed by meeting participants that the shrimp fishery is a "clean" catch that exhibits minimal bycatch; credit was given to industry for this. It was recommended that subsequent analysis be pursued to look into results of the Trawl Survey further, as well as shrimp bycatch results compared to bycatch results for other fisheries that occur on the Eastern Scotian Shelf. Such analysis was not encouraged for purposes of the framework assessment, rather should be pursued as a "special" project when time and resources permit. A recommendation was put forward that the Research Document make an explicit statement in the fishery section of the document that no discards of target species exist, and that full removals are accounted for in the fishery assessment.

DFO-Industry Trawl Survey

Survey Design – Random-stratified

The Trawl Survey design and sample locations were reviewed. The science lead noted that the portion of the survey in Misaine Hole consists of fixed stations given limited habitat in this area. In contrast, all other stations of the survey abide by a random-stratified survey design. A reviewer inquired as to where the survey area identified as LaHave clay was located; it includes 15 random stations. A member of the science team identified the area, clarifying that a lot of the clay areas do not have fishing, particularly in inshore, given depth and limited catch. As follow-up, a meeting participant inquired if the science team had evaluated overlap between fishing and the station locations in the LaHave clay area, as well as what bottom sediment map the team had been using. The science lead replied that the "Gordon Fader" map from 20 years ago was being used, and that evaluation between stations and fishing effort in this area had not been completed for the meeting.

It was agreed by meeting participants that the portion of the Trawl Survey in the LaHave clay area be reviewed to ensure it remained effective. It was suggested additional information on bathymetry and sediment grain size could be acquired to validate the 20-year old map, in order to ensure the survey locations align with habitat the industry fishes (i.e. finer grained sediments). Any mismatch has the greatest potential in the LaHave clay inshore area, so this would be a good area to focus effort. It was further suggested, when stratifying the survey, the overall objective of the survey should be kept in mind, including consideration of variation that may exist within each survey strata (if there is a lot of variation within a strata then re-stratifying may be required). The science lead noted that coefficients of variation associated with the

current survey design are not of concern, although it was agreed updated information should be used to re-evaluate the survey design when available.

Comparative Fishing (Testing the New Trawl)

The science lead briefly reviewed 'comparative' fishing results undertaken to test a new trawl used in the survey. Given that the results of the comparative testing have not been published in the literature, the science lead provided the following summary regarding change in the survey's trawl gear since 2011:

2011: It was determined new survey trawl gear was required; testing was conducted to provide comparison between the old and new trawl gear. Initial sets with the new gear suggested under-catching could be expected relative to the old gear. As a result, the new trawl gear was re-adjusted, with the results being in the range of what would be expected.

2012: Inclement weather, strong tides, and deeper water led to the new trawl not catching bottom, so weight was added to mitigate this problem.

2013: The new trawl gear weight had to be modified again. Four repeat trawls per survey area were undertaken during the day time when shrimp are believed to aggregate at the bottom.

2011-2013: Throughout this period, both the sampling protocol and new trawl gear were frequently adjusted. In general, it was found that the new trawl worked well in comparative fishing, with the exception of areas in deep water and/or strong currents. Trial testing over this period indicated that a heavier trawl led to higher catches, as compared to a lighter trawl, although the differences between the two were not significantly different.

2014: Door weights (40 lb) were installed and the catch was standardized with each trawl to account for differences in length and width between individual trawl sets.

2015: A new trawl mensuration system was acquired by DFO (the Trawl Survey previously relied on a backup system from the snow crab fishery survey). The new system relies on water temperature to identify depth (no depth sensor), although it is intended to add a bottom contact sensor at a later date when resources to acquire the sensor are available.

Biomass Dynamic Models

The science lead provided background on biomass dynamic models: conditions and assumptions of application. Briefly, biomass dynamic models are considered simple models that are based on biomass, catch, intrinsic population growth, and population carrying capacity. Modeled results are then fitted against three fishery abundance indices:

1. Trawl Survey biomass;
2. Standardized Catch Per Unit Effort (CPUE); and
3. Gulf CPUE (indices discussed below).

In 2009, a surplus production model applied to Eastern Scotian Shelf shrimp indices did not yield agreeable results; there was broad uncertainty around all modeled estimates (i.e., carrying capacity, Maximum Sustainable Yield, Biomass at Maximum Sustainable Yield, etc.). The model used in 2009 can be described as a "black box: - input to output - with no access to underlying model parameterization. In 2014, a 'Bayesian State Space BDM' model was applied, allowing for the manipulation of underlying parameters to explore uncertainty and minimize error. Inputs to the Bayesian State Space BDM remained the three abundance indices noted above.

Bayesian State Space BDM modeled results projected out to 2016, although the parameter estimates based on existing runs were not believable (e.g., fishery-related mortality values were

much higher than would be expected). In general, the modeled results indicated that without contrasting spawning stock size the stock-recruitment relationship could not be clearly delineated. The science lead noted that in order to do this additional historical data is required. The science lead further explained that, in the U.S. Gulf of Maine shrimp fishery, it was recently concluded that a State-Space model was not effective at informing stock dynamics, so the fishery retained a TLA for management purposes. A reviewer agreed with the conclusion that a Bayesian State Space BDM is not effective at informing stock/fishery dynamics for Eastern Scotian Shelf shrimp fishery; however it remained a worthwhile exercise to pursue for the framework.

Another reviewer suggested further effort be dedicated to looking at what has been done elsewhere in other North Atlantic-based shrimp fisheries, in order to identify alternate tools for stock assessment, as well as rule out tools that may not be reasonable for use in the Eastern Scotian Shelf shrimp stock assessment. The science lead acknowledged such review was not done in detail, and committed to exploring this a bit further in the Research Document (with reference to the recent U.S. Gulf of Maine shrimp fishery's rejection of a State-Space model). The reviewer suggested that looking at the Greenland shrimp fishery might be worthwhile, although that model includes cod (which is not a consideration of the Eastern Scotian Shelf shrimp fishery). A meeting participant inquired if lag effects were explored in the Bayesian State Space BDM model (i.e., does fishing affect biomass on multi-year increments). The science lead clarified the current model "walks" through on a year-by-year basis.

Meeting participants felt that an analytical approach (i.e. modeling approach) is not worth pursuing further at this time, given the results are inconclusive and the dynamics appear driven by environmental factors rather than fishing mortality. In general, it was agreed by meeting participants that focusing effort on refining the TLA is the best use of resources at this time, rather than exploring other analytical models which are likely to be difficult to apply to the Eastern Scotian Shelf shrimp fishery.

Traffic Light Approach

There was a discussion on the TLA used to inform management of the Eastern Scotian Shelf shrimp fishery. The science lead explained that a TLA consists of a range of indices used to evaluate and assess status of a fish stock holistically, in order to say something about overall stock well-being. For the Eastern Scotian Shelf shrimp fishery, there are four categories of indices within the TLA:

1. abundance;
2. productivity;
3. fishing; and
4. ecosystem.

The 'other' category refers to indices to be explored further for consideration within the TLA. The science lead reviewed the various indices for discussion with the reviewers and other meeting participants. Table 1 summarizes the overall meeting agreement regarding TLA indices.

Abundance Indices

Abundance indices are designed to evaluate stock size. For Eastern Scotian Shelf Shrimp, survey biomass and Catch Per Unit Effort (CPUE) indices are used to evaluate abundance. The survey biomass index is the product of the mean standard catch rate per stratum and number of trawlable units per stratum. Spawning Stock Biomass (SSB) has been adopted in the framework as a biomass reference point rather than a total biomass estimate. A reviewer commented that

SSB is a primary indicator in the TLA, driven by FA, so needs to include reference points. The science lead acknowledged the importance of characterizing uncertainty around SSB given it is used for reference points (noting SSB is inclusive of female and transitional shrimp). The reviewers sought clarity on the scaling of survey biomass results, as well as the procedure for weighting the survey catch, and agreed additional description would be added to the Research Document. It was then noted that survey catch rates in Shrimp Fishing Area (SFA) 17 may be biasing the results, and a meeting participant suggested a survey biomass index for each SFA be included in the Research Document, in order to demonstrate differences and similarities between SFAs. The science lead responded that the data is already presented by subarea in the assessment to demonstrate variability in any given year, although one overall survey biomass index is calculated for the entire stock (given that a single quota is set).

Three CPUE-based indices are included in the TLA:

1. unstandardized Trawl Survey CPUE;
2. unstandardized commercial CPUE (combined Gulf and Maritimes fleets); and
3. standardized commercial CPUE (separated Gulf and Maritimes fleets).

For each, CPUE was binned to show areas of effort (CPUE values per year), which allows comparison between survey biomass and catch. At the last stock assessment held in November 2014 (DFO 2015), the commercial CPUE indices decreased and the survey biomass index increased. The science lead clarified that when there is disagreement in behavior between the biomass and catch indices the assessment takes a closer look, particularly when survey biomass decreases with increasing CPUE indices. In 2014, however, the science lead explained that the increase in biomass relative to decreasing CPUE was not of concern. In discussion with harvesters, shrimp appeared to be abundant but were not being caught as effectively. A reviewer then asked if the divergence between the biomass index and CPUE indices was real or the result of the new survey gear being used. Further analysis undertaken for the framework meeting supported the observations of harvesters, as the data showed no signal of declining biomass throughout the 2014 fishing season. The analysis ruled out any divergence due to the new survey gear.

A meeting participant inquired as to the cause of a shrimp biomass increase observed on the Scotian Shelf from 1993-2005, with a subsequent plateau post-2015. The science lead commented that there have been suitable conditions for shrimp on the Scotian Shelf since the early 1990's (e.g., decrease in groundfish, suitable temperatures, and conservative harvest strategy). The meeting participant pointed to the high unstandardized CPUEs, asking where they occur and what the catch composition is like (wondering if there is a signal in these outliers). A reviewer explained that cohorts tend to stick together, so when encountered you get very high sets. The reviewer agreed, however, that the high unstandardized CPUEs suggest a strong signal and may warrant further exploration to determine if they are anomalous or signs of change. A meeting participant noted that outliers may be an artefact of how the data are presented and this should be considered in any further evaluation. The science lead emphasized that logbook data quality is important, especially when commercial CPUE indices are the main indicators in an assessment. This was supported by industry participants, who stressed that industry log book data is very accurate (industry recognizes the importance of logbooks to the fishery). It was suggested by a reviewer that the QC/QA protocol be documented in the Research Document, in order to highlight the good quality of data used to calculate these indices.

There was discussion on the standardized CPUE index. The science lead remarked that both the Gulf fleet and Maritimes fleet fish shrimp on the Scotian Shelf. The Gulf fleet vessels are

longer and fishing longer; hence, a standardized CPUE commercial catch index is estimated separately for each fleet. The science lead described how the unstandardized indices were calculated and showed plots comparing the standardized CPUE, Gulf CPUE, normalized CPUE, and survey biomass indices. When the standardized CPUE indices are compared to their mean (i.e., normalized CPUE indices), in 2014, the Maritimes standardized CPUE decreased more than the Gulf standardized CPUE. A reviewer commented that the normalized CPUE suggests biomass has been decreasing over the past decade. The science lead explained that the survey gear was not fishing properly in 2009, and was likely a gradual problem over the preceding years (first recognized in 2009). This may account for differences between the biomass and CPUE indices over recent years. The science lead emphasized the importance of considering the biomass and CPUE indices collectively. The overall objective is to see if these are good indicators, as checks and balances to each other, and this should continue to be incorporated into an on-going exploration of data. The survey index is emphasized in the overall FLA, as many of the indicators are derived from it. However, the CPUE indices also provide valuable comparative analyses of stock changes. One of the reviewers supported the recommendation that trap versus normalized CPUE should be added to FLA as an index.

A reviewer advised it would be useful to provide information in the Research Document on why other survey indices are not included in the FLA (e.g. Fisheries and Oceans Canada (DFO) Research Vessel (RV) trawl survey data series). In response, the science lead indicated that the DFO RV trawl survey data is not used due to low coverage, different gear, year, etc., but that this would be included in the document. In particular, it is worth noting in the Research Document the potential use of Trawl Survey data and snow crab survey data as surveys that should be explored more fully, which may provide further confidence in the existing shrimp biomass indices.

Productivity Indices

Productivity indices are designed to evaluate structure, viability, and growth of a stock. Sally-bag (Age 1), Age 2, and Age 4 indices are included in the FLA. The sally-bag length frequency is derived from the sally-bag samples, whereas the Age 2 and Age 4 indices are derived from modelled analysis (which incorporates a bit more uncertainty into these two indices). Further, Age 4 is considered an index of fishery recruitment, whereas the Age 2 and sally-bag samples are not reflective of recruitment into the fishery. Analysis indicates that the sally-bag index is a good predictor of the Age 2 abundance index. To date, maturity has responded to low sally-bag numbers, as an indicator of recruitment, despite SSB being in the healthy zone.

The science lead explained that while sally-bag, Age 2, and Age 4 indices are discussed, the assessment itself focuses more on the resultant survey length frequencies. A meeting participant noted that ageing is now being done on shrimp in the DFO Newfoundland and Labrador region using the eye stock of the shrimp, which is retained through the molts and can be used for ageing. It was suggested by the science lead that this was a tool that is being explored for Eastern Scotian Shelf shrimp, although it is not actively being pursued for use in stock assessment in the near term. The science lead agreed it would be helpful to generate an age-length key but, in consideration of existing resources, the present focus is to document methods and the preservation of samples.

There was discussion on the length-frequency index, and why it is used as an overmoss index within the FLA. A reviewer noted that overmoss does not represent a natural population distribution of length size classes; that is, a natural unfished population does not have an even distribution across lengths (i.e., it is either dome-shaped by biomass or logarithmic decay by abundance). The science lead clarified that the index is intended to be a measure of when the population is represented by an overall age-length. The reviewer responded that, if the index is

intended as a measure of recruitment trend, the eddy-log remains a more suitable index. Overall, the reviewer felt that utility of the length-frequency examinee index, as presented at the meeting, is questionable for use in the FI$_x$. The reviewer recommended exploration of alternate indices to better measure what the examinee index itself is trying to achieve.

The predator survey biomass index is broken down by predators that are known to have shrimp in their diet, including a sub-category of species with greater than 2% shrimp in their diet. A reviewer found it surprising that redfish have low shrimp in their diet given their habitat overlaps with shrimp habitat. The reviewer noted that redfish stomachs turnout when brought to the surface, so using stomach contents as a proxy may not give the overall picture due to partial regurgitation. Some meeting participants expressed concern that redfish is moving eastward and requested redfish be incorporated into the predator index regardless of stomach contents. It was suggested that the science lead review the literature to investigate redfish diet. A reviewer suggested the predator index only be evaluated every five years at the framework meeting given predator abundance is tied to longer-term ecosystem changes. In contrast, other meeting participants felt that the index should remain within the FI$_x$ given there are not a lot of other fish stock surveys on the Eastern Scotian Shelf. It was agreed the indicator would remain in the FI$_x$, as it further contributes to the biology and broader ecosystem approach. In addition, it was agreed the predator index would focus on a short list of species, with retrospective analysis to be undertaken before the next framework to again look at what sub-category of species have greater than 2% shrimp in their diet.

Fishing indices

Fishing indices are used to evaluate the influence of fishing on a stock. The science lead reviewed the exploitation index as a FI$_x$ indicator, noting that it focuses on the female portion of the shrimp population. It was also noted that size indices for count, maximum size, average female size, and size at sexual transition are still incorporated into FI$_x$. The confidence intervals applied to the maximum size index is large in any given year, although the long-term trend is still important for describing overall structure within the commercial catch. The science lead discussed the possibility of an egg health index. It was agreed by meeting participants that fishing effort should be included in the category as an index.

Ecosystem indices

Ecosystem indices are used to evaluate overall ecosystem influences on a stock (e.g., bottom temperature has been associated with successful shrimp recruitment). There is a general belief that as water temperatures increase, the incubation period may become shorter (resulting in a potential match-mismatch between shrimp hatching and the spring bloom over the long-term). A reviewer suggested it might be good to look at changes in bottom temperature relative to baby-keg results (lagged by a year), rather than compare bottom temperature to normalized CPUE. The science lead noted the comparison was done with surface temperature, but not with bottom temperature. Further, it was noted that a bottom temperature index is of importance given Eastern Scotian Shelf shrimp are found at the southern extreme of the species' thermal range. Continuing to report on water temperature as an index was emphasized as important by meeting participants. In contrast, sea surface temperature did not exhibit a relationship with normalized CPUE (lagged by five years), although the science lead suggested the index be retained in the FI$_x$ given the overall importance of temperature as an influential factor of shrimp productivity. A meeting participant commented that given there is an optimal range for temperature, the range should be used as the thresholds for temperature-related indices. A reviewer agreed that indicator thresholds should be as meaningful as possible, while continuing to use the more arbitrary 25th and 90th percentile thresholds for indicators that do not have specific boundaries (see discussion on indices thresholds below).

Capelin is a good indicator of shrimp production, although Capelin is not believed to be common on the Eastern Scotian Shelf (based on DFO R/V trawl survey results). Meeting participants recommended that this index be evaluated against shrimp bycatch rather than the trawl survey results for further consideration, although given Capelin is sporadic on the shelf, it was generally felt not to be a good indicator to use. The science lead suggested removing this indicator from the TLA. It was also noted that cod recruitment is an index for shrimp productivity, although it was advised that the index focus on cod adult abundance rather than recruitment as an index. It was agreed to retain this indicator, but refine it as suggested above. Similarly, meeting participants agreed turbot recruitment should be retained as an index within the TLA, but refined for size using stomach contents, in order to better understand how this index links to cod and Atlantic halibut. It was suggested further work be undertaken on developing a robust 'predator' index.

Other Indices

There was a discussion on other potential indices that could be considered for inclusion in the TLA. It was noted that many potential indicators measured within the Atlantic Zone Monitoring Program (AZMP) could be incorporated into the ecosystem category of indices of the TLA (e.g., North Atlantic Oscillation index, or NAO; Chlorophyll-A, etc.). It was suggested looking at Chlorophyll-A, spring bloom, and other AZMP-based indicators directly linked to environmental conditions might be insightful. In addition, trends in other species such as capelin, and cod could be used as additional indices to track overall environmental change on the Eastern Scotian Shelf. Similarly, it is believed that when environmental conditions on the Eastern Scotian Shelf are good for snow crab they are good for shrimp, and snow crab is a good indicator to continue to monitor. In general, a relationship between stock dynamics of shrimp of the North Atlantic and overall large scale environmental influences have been observed to occur; thus, any additional ecosystem indicators that might be available should be explored for inclusion in the TLA.

Thresholds for Indices

There was a discussion regarding the TLA 'green-yellow-red' indices thresholds, as under the current approach the reference points per indicator change each year (i.e., floating). The science lead requested guidance on whether meeting participants felt the various indices thresholds should remain 'floating' or be 'fixed'. It was noted that Precautionary Approach (PA) reference points for the abundance indices are based on 2000-2010 data, which is a time period believed to represent a productive period for the stock. Thresholds for the other indices are defined by the 33th and 66th percentile, so the thresholds change as new data is added. It would be nice to reach agreement in the present meeting on how thresholds are to be set for the next five year period. Table 1 summarizes the overall meeting agreement regarding thresholds for the various indices. It was agreed that prior to the next Eastern Scotian Shelf shrimp framework assessment that the chosen thresholds be evaluated retrospectively, in order to assess implications that fixing thresholds had on the overall stock assessment. Last, reviewers requested further analyses regarding fixed thresholds relative to a known period of stock productivity (i.e., 2000-2010). This analysis was circulated following the meeting for further consideration by reviewers (circulated: May 13, 2015).

TLA Summary

There was discussion regarding overall value of including a TLA "summary" score card in stock assessment advisory reports, as some meeting participants felt it could be interpreted as being the final advice. As such, these meeting participants felt that if the summary is not considered in the advice than it should be removed and could be replaced with an indicator summary. Similarly, a meeting participant noted that his organization was not in favour of a summary being

included in advisory reports, given it may have implications on possible management responses. It was agreed by meeting participants that this is to be discussed with the DFO resource advisor and industry members directly, rather than making a final decision at the framework meeting. As an alternative, it was suggested the primary and secondary indicators could be separated for summary reporting purposes.

Table 1. Summary of TLA indices used to inform the Eastern Scotian Shelf shrimp stock assessment. The 'Other' category refers to indices to be explored further for consideration within the TLA. A dash (-) indicates 'not applicable'.

Category	Index	Status	Threshold	Notes
Abundance	Unstandardized Trawl Survey CPUE	Keep	Fixed (2000-2010)	-
	Gulf CPUE	Keep	Fixed (2000-2010)	-
	Standardized CPUE	Keep	Fixed (2000-2010)	-
	Trawl Survey Coefficient of Variation	Keep	Fixed (2000-2010)	-
	Commercial Fishing Area (Dispersion)	Keep	Fixed (2000-2010)	-
	Trawl Survey SSB	Keep	Fixed (2000-2010)	-
	Trap Catch	**Add**	-	Add to TLA – include as an index
Productivity	Trawl Survey Belly-bag (Age 1)	Keep	Fixed (2000-2010)	-
	Trawl Survey Age 2	Keep	Fixed (2000-2010)	-
	Trawl Survey Age 4	Keep	Fixed (2000-2010)	-
	Length frequencies (survey & commercial)	Keep	Fixed (2000-2010)	Consider alternatives to evenness index
	Size at Sex Transition	Keep	Fixed (2000-2010)	-
	Maximum Shrimp Size	Keep	Fixed (2000-2010)	-
	Predator	Keep	Fixed (2000-2010)	Shortlist of species known to eat shrimp
Fishing	Count	Keep	Fixed (2000-2010)	-
	Exploitation Total	Keep	Fixed (2000-2010)	-
	Exploitation Female	Keep	Fixed (2000-2010)	-
	Female Proportion in Catch	Keep	Fixed (2000-2010)	-
	Female Size	Keep	Fixed (2000-2010)	-
	Fishing Effort	**Add**	Fixed (2000-2010)	Not in TLA – include as an index
Ecosystem	Population Evenness	Keep	Fixed (2000-2010)	Explore alternative indices to this
	Trawl Survey Bottom Temperature	Keep	Meaningful	-
	Spring Sea Surface Temperature	Keep	Meaningful	-
	Capelin	**Remove**	Fixed (2000-2010)	Remove from TLA
	Cod Recruitment	Keep	Fixed (2000-2010)	Cod adults rather than cod recruitment
	Turbot Recruitment	Keep	Fixed (2000-2010)	Cod and halibut stomach contents
	Snow crab Recruitment	Keep	Fixed (2000-2010)	-
Other	Atlantic Zone Monitoring Data	**Explore**	-	Research recommendation
	Snow crab Trap CPUE	**Explore**	-	Research recommendation

Harvest Control Rules

An HCR describes how harvest is intended to be controlled by management in relation to the state of some indicator of stock status (NOAA Fisheries Glossary). The science lead reviewed an approach to quantitatively link select TLA indices to an HCR. It was noted, however, that to do this successfully the TLA indicators would need to be weighted, which is difficult to do quantitatively. Overall, the science lead felt that quantitatively linking the TLA to an HCR was not possible and, given that the TLA approach to date has worked well with industry, it was recommended the TLA continue to be used to inform management of the fishery. A reviewer supported the conclusion that an HCR should not be pursued at this time. The reviewer advised, however, that the Research Document discuss in more detail why an HRC is not feasible for the fishery; that is, demonstrate in the Research Document how applying HCR in the past may have had detrimental effects on stock biomass.

Interim Advice and Triggers of Assessment

Fisheries and Oceans Canada has adopted a multiyear approach to science assessment procedures whereby the assessment cycle of a given fish stock includes a framework assessment, stock assessment, and stock update in interim years between framework and/or stock assessment meetings (a stock update for shrimp occurs every second year; i.e., assessment – update – assessment – update, etc.). Interim updates focus on identified indicators of stock status, and the peer review is held within the Department (no external participation). Given external participation is not supported for interim update assessments, meeting participants sought discussion on implementation of this approach for the shrimp fishery given industry funds several elements of science in support of stock assessment. In general, industry representatives are supportive of the overall interim update approach, but would prefer some industry representation be included in the interim update peer-review meetings (e.g., survey skipper). The science coordinator indicated he would convey this sentiment to the Regional Director of Science, DFO Maritimes region.

The science lead reviewed an approach to interim advice for the stock, including a discussion on content and triggers for a full stock assessment. It was agreed that the existing update report could incorporate additional information on belly-bag length frequency data, SSB composition, and a summary of ecosystem indicator results. The science lead also agreed to review other, similar fishery update reports for additional content ideas that may be relevant to the Eastern Scotian Shelf fishery (e.g. Gulf shrimp fishery). Triggers for a move from an interim update to a full stock assessment (during the interim update years) were then discussed. The science lead commented that triggers are difficult to identify without forward projections for comparison. A meeting participant inquired if a TAC could be set for two years, and the science lead replied that shrimp biomass can vary significantly between years, making this difficult (multi-year TACs are typically used in fisheries in which biomass is not expected to fluctuate significantly between years). It was agreed that thresholds of the core abundance indices and productivity indices would be used to guide triggers. The science lead, again, was advised to review what triggers may be used in other, similar fisheries.

Research Recommendations

It was recommended further analysis be pursued regarding bycatch within the shrimp fishery, as well as in comparison with other similar fisheries of the Eastern Scotian Shelf. In addition, it was recommended cod, turbot, and snow crab, as ecosystem indicators, be explored further in terms of how the species influence each other, and subsequently influence shrimp. Atlantic halibut could also be investigated given its abundance has increased over the past several years. The

science lead was further advised to explore additional indices that may help inform the TLA, including:

1. broader set of AZMP indicators to track potential ecosystem shifts that may relate to shrimp life history;
2. more refined predator index beyond those proposed at the framework meeting (e.g. redfish); and
3. review the age length evenness index and propose alternate indices that strive to achieve the same endpoint.

Last, it was recommended that the science lead consider reformatting the Research Document to reflect differences in hierarchy between "primary" and "secondary" indices including, but not limited to, removing individual indicator bar-charts in favour of a focus on plots/trends in the figures.

CONCLUSIONS

Primary conclusions of the meeting were: 1) the TLA should continue to be pursued and refined where possible to inform management of the fishery; 2) a Bayesian Model analytical approach yielded inconclusive results, so should not be pursued further at this time; 3) the current assessment approach does not support a direct linkage with HCRs and therefore HCRs cannot be pursued at this time; and 4) triggers for a move from an interim update to a full stock assessment (during the interim update years) should be identified using core indices, retrospective analysis, and in comparison with other fisheries. Overall, meeting participants agreed that provided the working paper incorporated comments made at the meeting, it was acceptable for publication as a Research Document. This Proceeding constitutes a record of the meeting discussion.

REFERENCES CITED

DFO. 2014. Eastern Scotian Shelf Shrimp Stock Status Update for 2013-2014. DFO Can. Sci. Advis. Sec. Sci. Resp. 2014/012.

DFO. 2015. Assessment of Northern Shrimp on the Eastern Scotian Shelf (SFAs 13-15). DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2015/004.

APPENDICES

APPENDIX 1: LIST OF MEETING PARTICIPANTS

Name	Affiliation
Bundy, Alida	DFO Maritimes / Ocean and Ecosystem Science Division
Covey, Michelle	DFO Maritimes / Population Ecology Division (BIO)
Cook, Adam*	DFO Maritimes / Population Ecology Division (BIO)
Couture, John	Unama'ki Institute of Natural Resources
Curran, Kristian	DFO Maritimes / Centre for Science Advice
Denny, Leon*	Eskasoni First Nation
Ferguson, Annie	New Brunswick Department of Fisheries
Hardie, David	DFO Maritimes / Population Ecology Division (BIO)
Hussey-Bondt, Laura	DFO Maritimes / Resource Management
Koeller, Peter	External Expert Reviewer
Lanteigne, Jean	Féderation Régionale Acadienne des Pêcheurs Professionels
Roussel, Eda	Association des Crevettiers acadienne du Golfe Inc.
Sameoto, Jessica	DFO Maritimes / Population Ecology Division (BIO)
Themelis, Daphne	DFO Maritimes / Population Ecology Division (BIO)
Vascotto, Kris	Nova Scotia Department of Fisheries and Aquaculture
Wheaton, Thomas	DFO Maritimes / Population Ecology Division (BIO)
Zisserson, Ben*	DFO Maritimes / Population Ecology Division (BIO)

* Attended Day 1 of meeting only.

APPENDIX 2: MEETING TERMS OF REFERENCE

EASTERN SCOTIAN SHELF SHRIMP FRAMEWORK

Regional Peer Review – Maritimes Region

April 14-15, 2015
Dartmouth, NS

Chairperson: Thomas Wheaton

TERMS OF REFERENCE

Context

The Northern or Pink Shrimp, Pandalus borealis, is the only shrimp species of commercial importance in the DFO Maritimes Region. The fishery consists of 28 DFO Maritimes Region-based licenses (fished by 9 vessels in 2014), mostly <65' length overall (LOA), and 14 DFO Gulf Region-based licenses (fished by 5 vessels in 2014) 65-100' LOA. All mobile licenses have been under Individual Transferable Quotas (ITQs) since 1998. A competitive trap fishery with 14 licenses (7 active in 2014) is largely restricted to Chedabucto Bay. The fishery operates under an "evergreen" management plan, which documents sharing agreements between fleet sectors. The status of Eastern Scotian Shelf shrimp was last assessed by DFO Science on November 27, 2014 (DFO 2015). This meeting will review the framework used to assess the Eastern Scotian Shelf shrimp.

Objectives

- Review the assessment framework and identify if alternative approaches to assessing the fishery can be identified:
  - review the Traffic Light Analysis and biological basis for considering each index to be relevant to the shrimp stock;
  - review alternate approaches to summarizing Traffic Light data that provides advice more directly related to Harvest Control Rules; and
  - review alternate assessment models, such as a biomass dynamic model.
- Identify how advice is to be provided in interim years versus full advice assessment years.
- Update descriptive information related to the fishery, the survey, biology, and ecosystem interactions of the target species.
- Evaluate bycatch of non-target species in observed trips in the shrimp fishery.

Expected Publications

Proceedings
Research Document

Participation

Fisheries and Oceans Canada, Science and Resource Management
Province of Nova Scotia and Province of New Brunswick
Aboriginal communities/organizations
Fishing Industry

References

DFO. 2015. Assessment of Northern Shrimp on the Eastern Scotian Shelf (SFAs 13-15). DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2015/004.

APPENDIX 3: MEETING AGENDA

EASTERN SCOTIAN SHELF SHRIMP FRAMEWORK

Regional Peer Review – Maritimes Region

April 14-15, 2015
George Needler Boardroom
Bedford Institute of Oceanography (BIO)
Dartmouth, NS

Chairperson: Thomas Wheaton

DRAFT AGENDA

14 April 2015	
09:00 – 09:15	Chair welcome
09:15 – 10:30	Update descriptive information of species and fishery (biology, survey, ecosystem interactions, target species)
10:30 – 10:45	Break (light refreshments)
10:45 – 12:00	Evaluate bycatch in fishery
12:00 – 13:00	Lunch (not provided)
13:00 – 14:15	Review biological basis for indices and Traffic Light analysis
14:15 – 14:30	Break (no light refreshments)
14:30 – 16:00	Review biological basis for indices and Traffic Light analysis (Continued)
16:00 – 16:30	Chair (close for day)
15 April 2015	
09:00 – 09:15	Chair welcome
09:15 – 10:30	Discuss approach for advice in interim years versus assessment years, and triggers of an assessment within interim years
10:30 – 10:45	Break (light refreshments)
10:45 – 12:00	Review alternate approaches to Traffic Light approach related more closely to Harvest Control Rules
12:00 – 13:00	Lunch (not provided)
13:00 – 14:15	Review alternate approaches to Traffic Light approach related more closely to harvest Control Rule (continued)
14:15 – 14:30	Break (no light refreshments)
14:30 – 16:00	Review alternate assessment models
16:00 – 16:30	Chair (close for day)